NAVAL AVIATION SYSTEMS TEAM

Solid Propellant Gas Generator Workshop
National Institute of Standards and Technology
June 1995

NAWC Weapons Division NAVAL AIR WARFARE CENTER

Fire Extinguishing Pyrotechnics

Jim Hoover, Russ Reed
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Weapons Survivability Laboratory

Naval Air Warfare Center Weapons Division
China Lake

Unclassified

IN: Yang, J.C., et al., Editors, Solid Propellant Gas Generators:
Proceedings of the 1995 Workshop, NISTIR 5766, June 28-29, 1995,
75-88 pp, 1995

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Goal and Objective

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- Goal from the Next Generation Plan (NGP):

> "The program goal is to develop and demonstrate, by 2004, environmentally-friendly, user-safe processes, techniques and fluids that meet the operational requirements currently satisfied by halon 1301 systems in aircraft, ships, land combat vehicles, and critical command and control facilities."

- Objective for China Lake Gas Generator Efforts:

> Develop and demonstrate active, chemical and chemical precursor flame suppressing gas generators (FSGG) that comply with the NGP goal.

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Fire Science &Technology Panel FY95 Participants

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Joe Benavides, NAWCWPNS Albuquerque	A28N103
Prof. Matt Kelleher, Naval Postgraduate School	Me/KK
Leo Budd and Hardy Tyson	418300D
Wayne Doucette and Gill Cornell	473A00D
Dr. Warren Jaul, Brenda Allen and Rodney Harris	473110D
Vicki Brady	473410D
Dr. Kelvin Higa, Dr. Rich Hollins and Dr. Curt Johnson	474220D
Thom Boggs	474300D
Dr. Jim Hoover and Dr. Russ Reed	474310D
Les Bowman and Dr. M.J. Lee	474320D
Dr. Jo Covino, Dr. Ilzoo Lee and Ross Heimdahl	474330D
Jay McClellan	528400D
Ross Davidson, Dick Rivers and Wil Simoneau	824220D

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Fire Science &Technology Panel FY95 Accomplishments

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- Coordinated local review of DDR&E proposal drafts "Next Generation Fire Suppression Technology" ($48M/8 years)
- Conducted China Lake Fire S&T Workshop and established working group to promote Fire S&T work within NAWCWPNS
- Sponsored Fire S&T marketing brochure and electronic media describing China Lake RDT&E capabilities and expertise
- Conducted Navy-wide Fire S&T Workshop (14 &15 Mar 95 at NASNI) attended by NAVAIR, NAVSEA, ONR, NRL, NAWCAD (Lakehurst and Warminster), NAWCWPNS, NPG and Federal Fire Dept.
- Obtained NAVSEA sponsorship for Shipboard Magazine Fire Protection Program ($2.5M over 5 years) and JTCG sponsorship for Pyrotechnic Fire Extinguisher R&D.
- Developed networked teams (Industrial/Academic/Gov't labs) for pursuing major outside sponsorship (i.e., SERDP) and in-house discretionary projects
- Participated in international Fire S&T meeting and NIST Workshop

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Gas Generator Formulation Work History at China Lake

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1979 High Nitrogen Binder (GAP) Work (Funded by ARC)

Goal: No Ammonium Nitrate (AN)

Significance: High nitrogen binders attractive for gas generators

1980s High Nitrogen Binder Work (Funded by ONR/ONT)

Collaboration with Thiokol (Dr. Manser), later with Aerojet

Goal: Alternative high nitrogen compounds - no AN

Approach: demonstrate azidooxetanes as good as PEG E-4500 (Dow), tetrazoles and GAP

1979-1982 NAVAIR Gas Generator Technology

Amoco MK-6 (N-28 comp.), AN/PE binder, 2000-2200°F, 0.06"/s

Goal: 1500°F, 1"/s, noncorrosive, no particulates

Approach: High nitrogen compounds yield less H_2O, CO, CO_2; new deflagration mechanism for azides and tetrazoles, driving force is high ΔH_f

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Gas Generator Formulation Work History at China Lake

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1983-1985 NAVSEA Submarine Deballasting Gas Generators

Goal: High N_2 (inert), noncondensable gases, tailorable sustained higher burn rate than AN (>0.5"/s)

Approach: High nitrogen compounds with high nitrogen binders (i.e., hydroxyethyltetrazoles)

1987 Patent on Pyrotechnic Fire Extinguisher (PFE) Compositions

1992 Flame Suppressing Gas Generator (FSGG)

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Gas Generator Comparison

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	FSGG	Double Base	Am. Nit.	Olin
Composition	azides/prec.	NC/plast.	AN/rubber	propr.
Products	>N_2/chem.	N_2/CO/CO_2 H_2O/C	N_2/CO/CO_2 H_2O	N_2... (~50%)
Rel. Temp.	cool	hot	hot	hot
Deflagration	flameless	flame	flame	flame
Rel. Rate	fast	slow	slow	fast
Gas Quality	clean	dirty (C)	clean	filtered
Application		starter	SM/APU	Air Bags

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FSGG-02 Propel ant Concept and Ca cu ated Burn Rate

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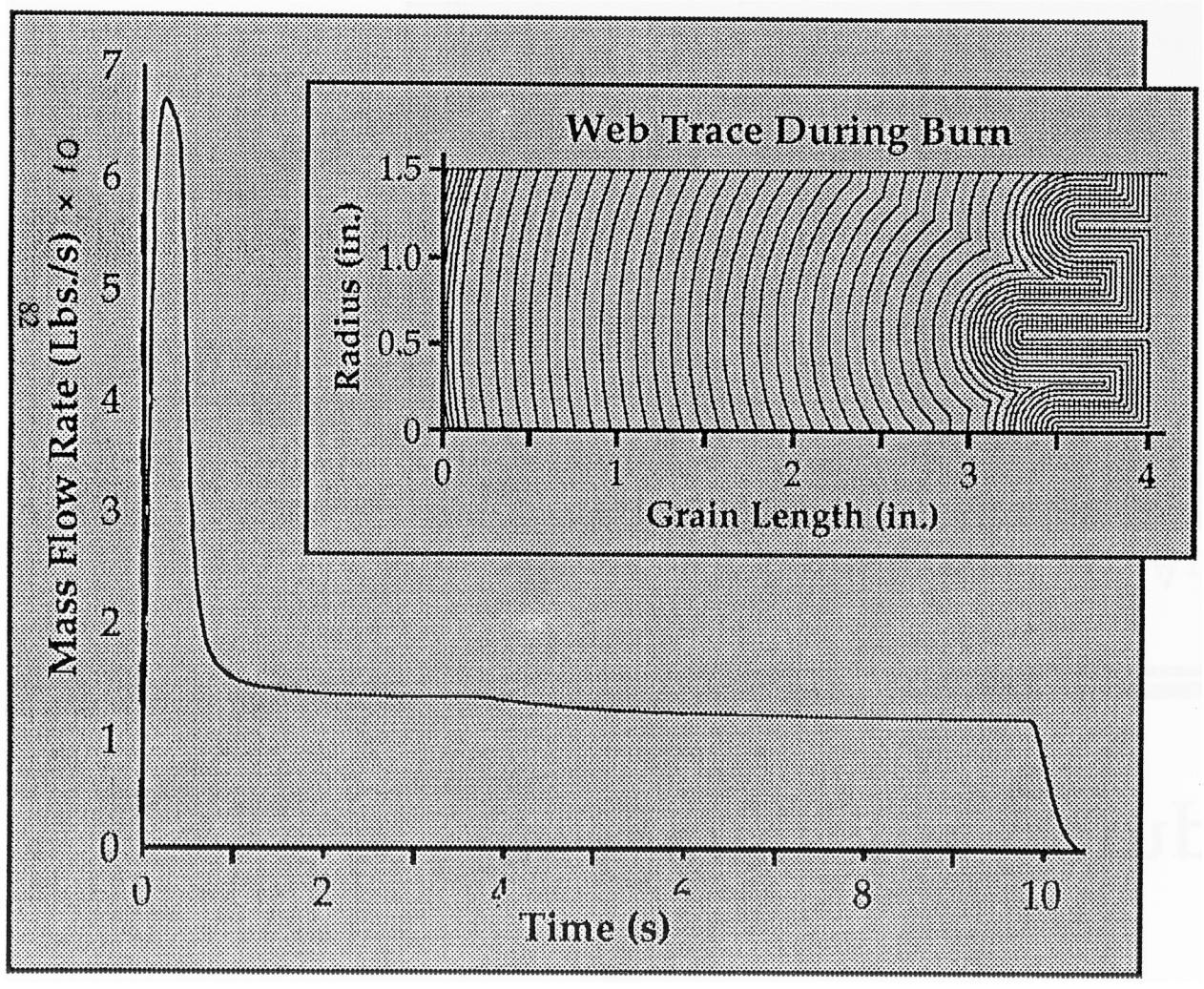

Initial Concept

1.5 Lb_m propellant

Density:
0.0542 $Lb_m/in.^3$

CStar: 4000 ft./s

Burning Rate:
0.50 in./s @ 1000 psia

Slope: 0.50

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Gas Generator T&E History at China Lake

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Weapons Survivability Laboratory Facilities

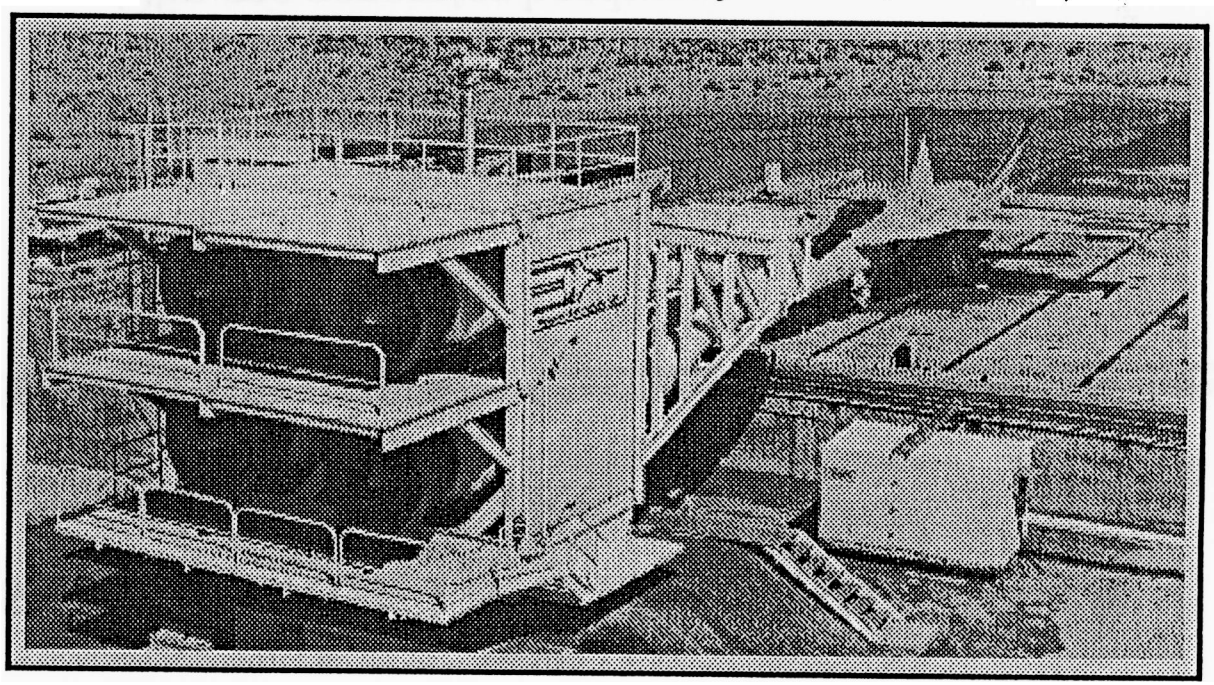
Test Equipment / Instrumentation / Ballistic Threats
Test Sites / Fabrication Capabilities

High Velocity Airflow System (HIVAS)

Airflow Source:
Bypass airflow ducted from 4 TF-33 P11 engines

Velocity Ranges:
160-550 knots over 18 ft.^{2}
100-300 knots over 35 ft.^{2}
40-120 knots over 110 ft.^{2}

Rotatability: 360° to cover 6 test pads



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Gas Generator T&E History at China Lake

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Testing Program:
F/A-18 Dry Bay Simulator

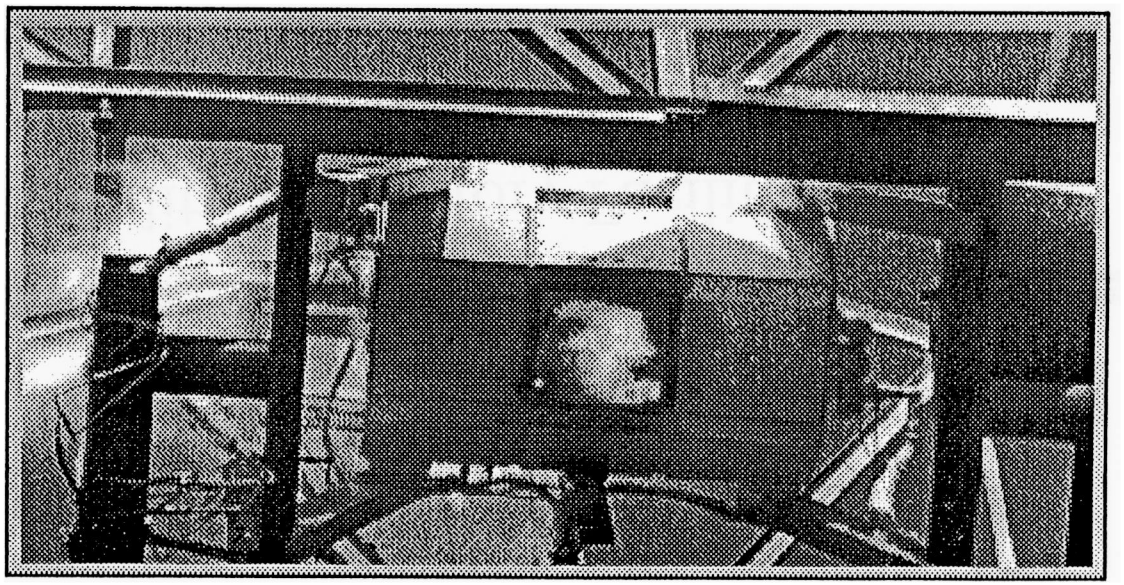
Dates: April - June 1993

Program Sponsor(s):
Navy, F/A-18

Technical Support:
Northrop,
McDonnell-Douglas,
Olin

Significance:
First demonstration of gas generator (Olin) effectiveness in real-scale scenario sim.

Test Conditions:
Real-scale F/A-18 dry bay simulator with fuel cell and clutter, HIVAS 450-500 knots,
Halon 1301 and FM-200 baselines,
Ballistic ignition (small arms, 12.7 - 30 mm),
Olin gas generator hardware



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Gas Generator T&E History at China Lake

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Testing Program:
V-22 Wing Dry Bay Simulator

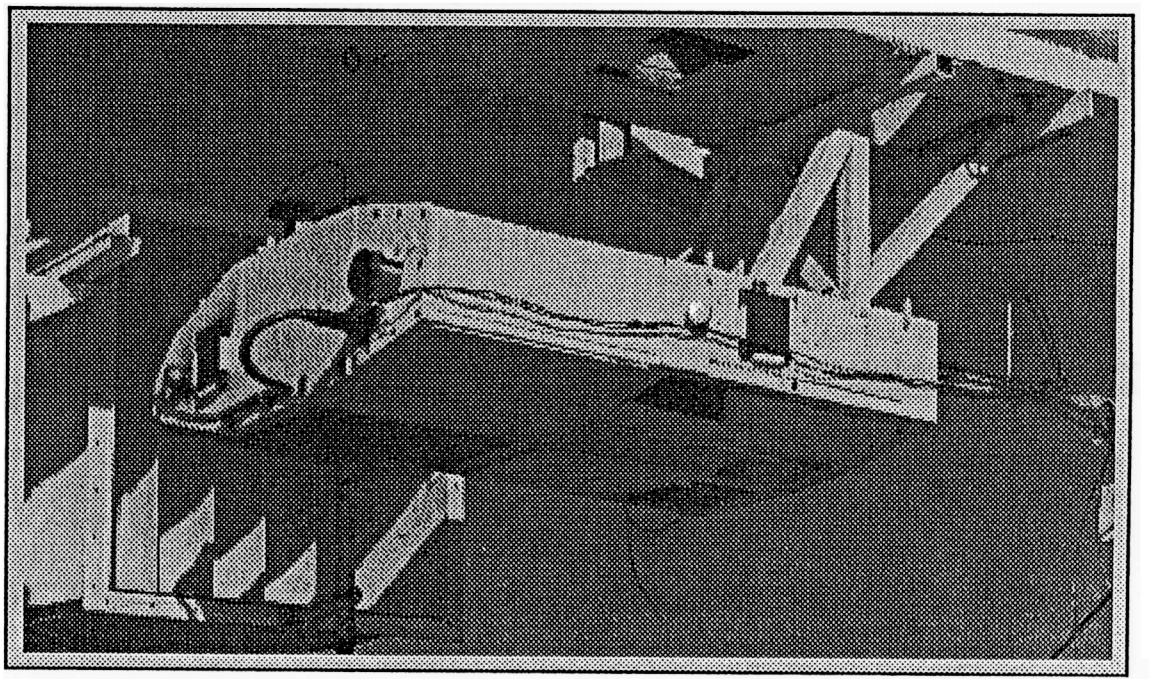
Dates: Dec. - Jan. 1994

Program Sponsor(s):
Navy, V-22 (CDR Curtis)

Technical Support:
Bell-Boeing, Olin

Significance:
Active suppression needed and demonstration of gas generator (Olin) effectiveness in real-scale simul. scenario

Test Conditions:
Real-scale V-22 wing dry bay simulators (3) with fuel cell and clutter, HIVAS 250 knots, Halon 1301 and FM-200 (RFE) baselines, Ballistic ignition, Olin gas generator hardware



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Gas Generator T&E History at China Lake

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Testing Program:
F/A-18 Engine Nacelle Simulator

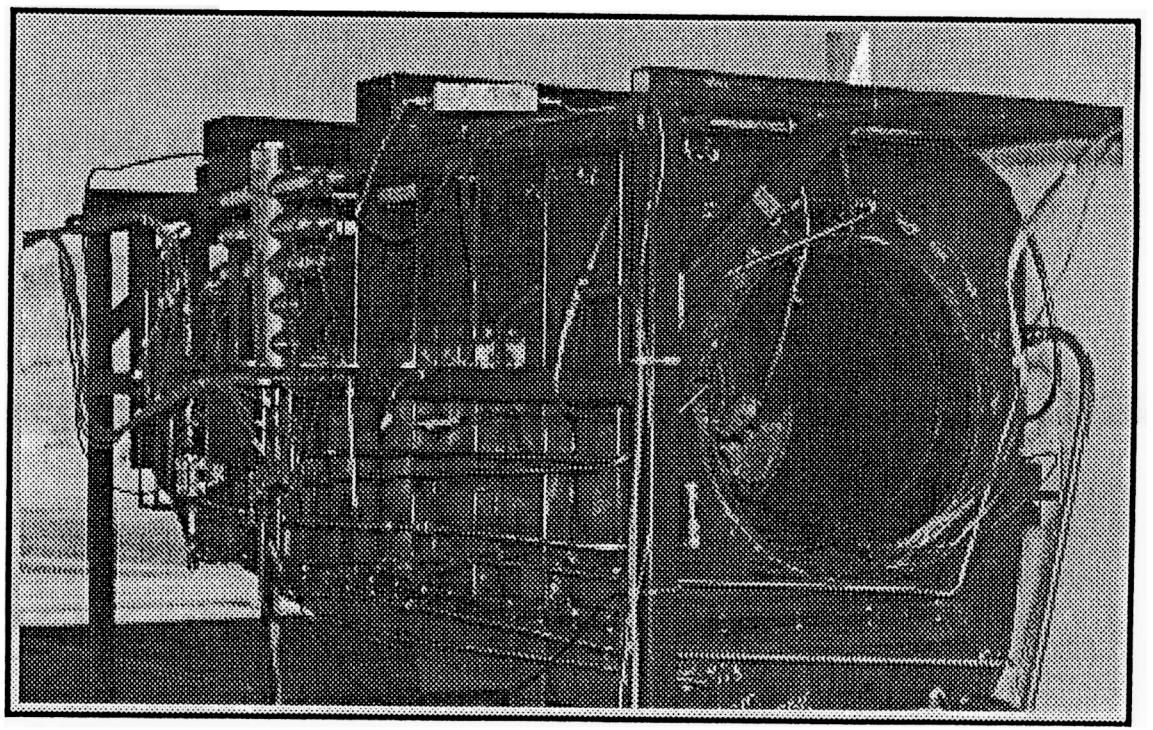
Dates: Aug. - Nov. 1994

Program Sponsor(s):
Navy, F/A-18
NAVAIR (Mr. Homan)

Technical Support:
Northrop, McDonnell-Douglas, Olin

Significance:
Demonstration of gas generator (Olin) effectiveness in real-scale scenario sim.

Test Conditions:
Real-scale F/A-18 engine nacelle simulator with clutter and air flow, Halon 1301 baseline, spark ignition and ballistic ignition wrap-up, Olin gas generator hardware (manifolded, unfiltered)



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Future Gas Generator T&E at China Lake

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- **F/A-18 E/F Fuselage Dry Bay Fire Suppression Test, FY95**
  Sponsor: Navy (CPT Dyer)
  Tech. Support: Northrop, McDonnell-Douglas, Olin
  - Real-scale E/F modified C/D model aircraft
  - Proof of concept for gas generators with ballistic ignition
  - Airflow (HIVAS) 450-500 knots

- **V-22 Midwing Gearbox Fire Suppression Test, FY96**
  Sponsor: Navy (CDR Curtis)
  Tech. Support: Bell-Boeing, Olin
  - Real-scale V-22 structure
  - Proof of concept for gas generators
  - Airflow (HIVAS) 250 knots

- **AV-8B Dry Bay and Aft Wheelwell Fire Suppression Test**

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Fire Protection RDT&E
Future Efforts

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Continue Support of NAVAIR and NAVSEA Programs through:

- Weapons Survivability Laboratory
- Fire Research Office (Les Bowman)
- Fire S&T Networks Panel (multi-competency)

Continue Team Building Efforts through S&T Networks to address:

- DDR&E's Next Generation Plan BAA (SERDP type proposal)
- Market ILIR discretionary support for "Superagents" research
- Market support for scale-up and loading of FSGG formulations
- Unclassified/unlimited dist. information services via Internet (WWW, etc.)

Rapid, Low-cost, Total Quality Response to DoD Needs